DEFORMED CARBONATITE–SYENITE COMPLEX IN THE WESTERN SIERRAS PAMPEANAS OF ARGENTINA: U-Pb SHRIMP ZIRCON AGE AND ISOTOPE (Nd, Sr) CONSTRAINTS

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The association of alkaline igneous rocks (particularly nepheline syenites) with carbonatites is common in rift settings. Deformed, i.e., variably foliated examples are a special case, in which they apparently match ancient sutures in basement regions (Burke *et al.* 2003). We describe here the case of a Neoproterozoic deformed syenite–carbonatite dyke from a Grenville-age terrane in the Sierra de Maz, one of the Western Sierras Pampeanas of Argentina. To our knowledge this is the first recognition of such a rock assemblage in the basement of the Central Andes, which could prove to be of economic importance.

The Maz deformed syenite–carbonatite complex forms a dyke ca. 4 km long and of variable thickness (max. 120 m), striking 340–345º along the eastern margin of the Sierra de Maz and dipping 65–70º E. Host rocks to the complex belong to the Grenville-age Maz Central Domain which underwent granulite facies metamorphism at *ca*. 1,2 Ga and retrogression under amphibolite facies conditions at 431 ± 40 Ma (Casquet *et al.* 2007, and references therein). The dyke is largely concordant, but locally discordant, to the foliation of the host rocks.

Homogeneous elongate medium- to coarse-grained syenite bodies and enclave-rich fine-grained foliated biotite carbonatite are the two main lithologies. Besides syenite spheroids, the carbonatite hosts a number of other types of enclaves, notably large (pegmatitic size) isolated crystals of albite and biotite, coarse-grained mafic enclaves (one type is aegirine-augite variably converted to katophorite, and a second type consists of coarse-grained magnetite and biotite with accessory primary calcite, apatite and pyrochlore), and enclaves of the host gneisses and amphibolites with the internal foliation sometimes at a high angle to the carbonatite foliation. Enclaves can locally be very abundant, giving the outcrop a breccia-like aspect.

The carbonatite consists of calcite (with up to 1.4 wt. % SrO, and 0.41 wt. % ΣLREE), 10 to 30 % modal biotite, abundant anomalous biaxial F-rich apatite and minor magnetite, zircon, very scattered U-rich pyrochlore and columbite. The syenites are coarse-grained rocks that are locally foliated. They consist of albite, biotite and minor microcline. K-rich nepheline (Ks_{21-22}) was found in several samples. Accessory minerals are zircon, apatite and minor pyrochlore. Foliated syenites are medium-grained and show a granoblastic orientation of albite and preferred orientation of biotite.

The syenites are Na-rich alkaline rocks with high Zr contents (716–1920 ppm). They show strong decrease in P_2O_5, REE_{total}, Sr and Y with SiO_2. Carbonatites are silico-carbonatites that have steep, LREE-enriched patterns with no Eu anomalies, and plot within the field defined for most world-wide carbonatites.

$^{87}Sr/^{86}Sr$ values in calcites are very unradiogenic (0,70275 – 0,70305). Because of the high Sr contents (3108–8493 ppm) present values can be taken as a close estimate for the initial Sr isotope composition of the carbonatite magma at the time of formation. When carbonatites and undeformed syenite data are plotted as $^{87}Rb/^{86}Sr$ *vs.* $^{87}Sr/^{86}Sr$, an isochron age of 582 ± 60 Ma (MSWD = 1,8; Sr_i = 0,7029) is obtained. Sm–Nd data yield epsilon values at the reference age of 570 Ma (see below) of between +3,3 and +4,8, also suggesting a major contribution to the Nd isotope composition of the magma from a depleted mantle source. Nd model ages (T_{DM}*) between 764 and 986 Ma are significantly older than those obtained from the Rb–Sr data and zircon chronology (see below). A $^{147}Sm/^{144}Nd$ *vs.* $^{143}Nd/^{144}Nd$ plot roughly fit an errorchron (MSWD = 10,2) with a very large age uncertainty (751 ± 460 Ma). The poor fit suggests that whole-rock Sm–Nd systematics may have been perturbed after magmatic crystallization; chemical and geochronological evidence from zircon is consistent with this interpretation

SHRIMP U–Pb spot analysis of both a complexly-zoned zircon megacryst from one syenite sample and a zircon concentrate from another syenite samples shows a total range of ^{206}Pb–^{238}U ages between 433 and 612 Ma. Textural evidence and statistical handling of the ages indicate four possible zircon growth events. The youngest, at 454 ± 4 Ma, is obviously related to the Famatinian metamorphism. The second group of ages at 520 ± 4 Ma, given by about 20% of the determined ages is similarly related to rejuvenation at the time of the Pampean orogeny (Rapela *et al*. 1998b). At this stage of interpretation it is difficult to decide whether each of the two older events (564 ± 4 and 588 ± 6 Ma) that together account for 65% of the data truly represents a discrete event or whether they would be best taken to yield a mean age of ~570 Ma. The most definitive statement that can be made concerning the age of this carbonatite complex is that it is at least 570 Ma old.

An argument in favour of dyke injection at *ca*. 570 Ma is provided by the Rb–Sr systematics. The isochron age (582 ± 60 Ma) is within error of the U–Pb zircon ages. Resetting of the Rb–Sr chronometer at *ca*. 570 Ma would imply a significant exchange of Sr between the carbonatite and the syenite reservoirs because of the high Sr content of both calcite in carbonatite and syenite. However with the exception of the more deformed and recrystallized syenites such a process is not supported by petrographic evidence. Moreover, no geochronological evidence exists in Western Sierras Pampeanas for a regional thermal event at *ca*. 570 Ma intense enough to reset the zircon U–Pb and the bulk rock Rb–Sr systems. We thus favour an age of *ca*. 570 Ma, i.e., Ediacaran, for the Maz carbonatite-syenite complex.

Recent palaeomagnetic evidence suggests that a new ocean, the Clymene Ocean, existed at *ca*. 550 Ma between the Amazonia–Rio Apa mainland on one side, and the Rio de la Plata, Kalahari and Australia on the other (Trindade *et al.* 2006). Opening of this ocean could not be older than *ca*. 570 Ma, the age of the youngest detrital zircons found in the Puncoviscana Formation – a sedimentary sequence deposited along the Kalahari margin of this ocean and moved to its present position adjacent to the Rio de la Plata craton by right lateral displacement during the Pampean collision (Rapela *et al.* 2007). Rifting at *ca*. 570 Ma leading to opening of the Clymene Ocean is the most probable scenario for the intrusion of the Maz carbonatite – syenite complex. Magma source was a depleted mantle. Moreover contamination of magmas by a poorly radiogenic old continental crust of Grenville-age is inferred from Sm–Nd data.

REFERENCES

Burke, K., Ashwal, L.D. and Webb, S. 2003. New way to map old sutures using deformed alkaline rocks and carbonatites. Geology. 31: 391-394.

Casquet, C., Pankhurst, R.J., Rapela, C., Galindo, C., Fanning, C.M., Chiaradia, M., Baldo, E., González-Casado, J.M. and Dahlquist, J.A. 2007. The Maz terrane: a Mesoproterozoic domain in the western Sierras Pampeanas (Argentina) equivalent to the Arequipa-Antofalla block of southern Peru? Implications for Western Gondwana margin evolution. Gondwana Research (doi: 10.1016/j.gr.2007.04.005).

Rapela, C.W., Pankhurst, R.J., Casquet, C., Baldo, E., Saavedra, J., Galindo, C. and Fanning, C.M. 1998. The Pampean orogeny of the southern proto-Andes: Cambrian continental collision in the Sierras de Córdoba. *In*: Pankhurst, R.J. and Rapela, C.W. (eds), The Proto-Andean Margin of Gondwana. Geological Society of London, Special Publications. 142: 181-217.

Rapela, C.W., Pankhurst, R.J., Casquet, C., Fanning, C.M., Baldo, E., Gonzalez-Casado, J.M., Galindo, C. & Dahlquist, J.A. 2007. The Río de La Plata craton and the assembly of SW Gondwana. Earth Science Reviews. 83: 49-82.

Trindade, R.I.F., D´Agrella-Filho, M.S., Epof, I. & Brito Neves, B.B. 2006. Paleomagnetism of Early Cambrian Itabaiana mafic dikes (NE Brazil) and the final assembly of Gondwana. Earth and Planetary Science Letters. 244: 361-377.